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REPORT
ON
SCALE-INSECTS OF THE ORANGE,
WITH
REMEDIES AND THEIR APPLICATION.

BY

H. G. HUBBARD,
SPECIAL AGENT U. S. DEPARTMENT OF AGRICULTURE.
[With note by C. V. Riley]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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SCALE-INSECTS OF THE ORANGE.

REMEDIES AND THEIR APPLICATION.

By H. G. HUBBARD, SPECIAL AGENT,

CHARACTERIZATION OF THE SPECIES.

In devising practicable remedies for Scale-insects, the first factor of importance is seen to be that there are several kinds of these insects which yield to treatment in very different degrees. Without entering upon the subject of classification, which has already been fully treated in reports of the Department of Agriculture, we may, for the purposes of the present article, divide those that infest trees of the orange family into two groups—the naked Coccidæ (*Lecaninæ*), and those which are protected by a horney scale (*Diaspinæ*). The former give comparatively little trouble; their colonies rarely increase sufficiently to endanger the life of a tree, and are invariably checked—often exterminated—by their parasites. Moreover, their unprotected bodies are vulnerable and exposed to the action of strong lye or soap solutions and other insecticides.

The Scale-armored *Diaspinæ* are much more destructive in their ravages, and their astonishing powers of reproduction frequently enable them to outstrip their natural enemies. Owing to their protective covering they are but little affected by most of the washes and insecticides in general use. Of this group three species are known to me, and are universally distributed in orange groves throughout Southeastern Florida.

Mytilaspis Gloverii (Packard), the common "Long Scale," or "Oyster-shell Scale," is familiar to orange-growers as a dark-brown, or yellowish particle, very elongate in form, which infests the twigs and branches, appearing finally upon the leaves, and, more rarely, upon the main trunk of the tree.

Mytilaspis citricola (Packard), to which the name "Purple Scale" may be given, is somewhat larger than the preceding, which it resembles in general form, and with which it is commonly confounded. It is, however, usually dark-purple in color, individual scales varying to red-brown. Like the Long Scale it is found upon the twigs and branches, and it is apt to infest the lemon, citron, and those varieties of orange which have large oil cells (Tangierine, &c.).

Parlatoria Pergandii, Comstock, is a small, thin scale, nearly circular in outline. In color it so closely resembles the bark that it very often escapes notice. In fact, many persons whose groves are suffering from the attacks of this scale are unaware of its presence. It infests by preference the trunk and larger branches, and to these it generally confines itself until every portion of their surface is thickly coated and the young bark-lice can no longer find places to plant themselves. It is also frequently seen upon the fruit. The young often form their scales underneath or over the mother, and are found piled upon one another, in a manner never seen in the other scales. From their resemblance to coating of fine chaff, or bran, upon the trunk of the tree, I have calle this the "Chaff Scale." These three scales are so universally distribu ted that it is safe to say no bearing orange tree exists in Southern an Middle Florida upon which one or the other cannot be found.

The Long Scale (*M. Gloverii*) is the most destructive, while it is th most readily destroyed. The Purple Scale (*M. citricola*) is in my expe rience rarer, although not less injurious than the Long Scale, to th trees which it infests. It is somewhat more difficult to kill than th latter. The Chaff Scale (*P. Pergandii*) is hardly less common than th Long Scale and is very frequently associated with it. Of the three i is decidedly the most difficult to exterminate, owing, in part at least, t its habit of piling or lapping one over the other. Except upon ver young trees it seldom does permanent injury, and is much less to b feared than the other two species. Its thinner scale renders it liable t the attacks of enemies to a much greater extent than the Mytilaspis Scales, and they often cause its complete disappearance from a tree.

The life-history of these Scale-insects has been so recently set forth by Professor Comstock (Department of Agriculture, Report 1880), that a full recapitelation of the subject here is unnecessary. In treating of remedies three periods in the development of the insect require to be noticed.

The PERIOD OF MIGRATION, during which the newly-hatched larvæ are possessed of legs, and wander over the tree, lasts but a few hours, or at most one or two days, after which the young coccids fix themselves upon the bark and begin to suck the juices of the plant.

The PERIOD OF GROWTH, during which the insect loses its legs, under goes several molts, and excretes a scale, varies in duration according to the season of the year, from one to two months, and is lengthened by cool, and shortened by warm, weather.

The PERIOD OF INCUBATION, during which the eggs are deposited and hatched under the fully-formed scales, varies greatly in duration, depending upon the season and temperature. In February, with uninterrupted warm weather, the females of the Long Scale (*M. Gloverii*) continue to deposit their eggs during sixteen or eighteen days. The eggs hatch in summer in a week or ten days. In winter the time is extended indefinitely by cold, which is, however, never of sufficiently long continuance to cause an entire suspension of the process. The young, after hatching, remain many days under the parent scale, if the weather is unfavorable.

Up to the time of the first molt the bark-lice are easily destroyed by insecticides of moderate strength, but during the remainder of their existence they are protected by the scale, a horny covering, excreted by the insect, and entirely covering its body above. The under layer, or ventral scale, is somewhat thinner, and, although perhaps a separate piece, is firmly united to the upper scale at the edges, so that the latter appears to be turned under at the sides. In *Mytilaspis* the ventral scale forms flanges along the sides, which do not quite meet along the center line, but in *Parlatoria* it forms an unbroken shield, which entirely separates the body of the insect from contact with the bark. This more perfect protection from below renders the Chaff Scale more difficult to destroy by means of external applications. The scale is permanently fastened upon the tree, and so closely molded to its surface that the pores of the bark, or the stomata of the leaf, are seen plainly stamped upon it when removed.

As the scale, like the shell of the snail, is formed by successive additions, and keeps pace in its growth with that of the body of the insect within, its vulnerable point is the growing end, and there are times during its formation when the posterior extremity of the insect projects slightly beyond it and becomes exposed to the action of penetrating liquids. This is particularly the case at the critical periods when the coccid sheds its skin. But when the scale is fully completed and tightly sealed at all points, no insect is more difficult to reach and to destroy.

The substance of which the upper scale is composed is impervious to most liquids, and is not soluble in acid or alkaline solutions strong enough to injure the plant. It resists the action of oils and of bisulphide of carbon, an almost universal solvent. Many insecticides are therefore inoperative, and all insoluble substances, such as sulphur, &c., are clearly useless, as they do not reach the eggs or mature insects. The thinner ventral scale is not impervious to the more volatile oils or to alcoholic solutions, some of which reach and kill the insect by penetration through the bark.

From the foregoing outline of their structure and history it will be seen that for a brief period only in their development these insects are easily assailable. During the period of migration the tender young may be destroyed by solutions of whale oil soap, lye, &c., sprayed over the trees; and were the eggs hatched simultaneousty and the broods clearly defined, as with many other insects, their extermination would be a matter of no difficulty. This is, however, not the case; the open winters in Florida permit continuous breeding throughout the year, and at all seasons scales in every stage of development are found upon the trees. There are, however, times when the number of migrating young reaches a maximum, and the application of remedies then proves particularly effective.

Three such periods occur: the first in spring, usually in March, but sometimes extending into April; the second in June or July; the third in September or October. During the winter months, if the season is a mild one, there is a fourth very irregular brood beginning in January and continuing through this and the following month. The spring brood that follows is greatly confused. In cold and rainy winters, like that of 1880–'81, the hatching process is retarded, and the appearance of the larvæ on the return of warm weather is more nearly simultaneous than in ordinary seasons.

The eggs of coccids, as is the case with all insects, have much greater vitality than the insects themselves. Many substances which destroy the living insects have no effect upon their eggs. The periods in which the majority of the scales are filled with eggs are therefore those in which the application of remedies is likely to prove least effective, and it becomes important to know the seasons at which these maxima occur. They immediately precede the appearance in numbers of the migrating larvæ, and may be stated to include generally the months of February, May, and August, and the winter months from November to January.

The above data concern more particularly the common Long Scale (*M. Gloverii*). The broods of Chaff Scale (*P. Pergandii*) have not been as carefully studied at all seasons, and may be found to have somewhat different periods. During the past winter (1881–'82) I have found this scale to be about two weeks in advance of the Long Scale. The Purple Scale (*M. citricola*) has not been continuously observed, but seems to have the same brood periods as Long Scale.

THE WORK OF ENEMIES AND PARASITES.

Numerous enemies prey upon bark-lice in all their stages, and always greatly reduce their numbers. Besides occasional enemies, such as the sucking bugs, and other predatory insects, which are general feeders, there are others which live almost or quite exclusively upon the Coccidæ. Some of these confine their attacks to particular kinds of Scale insects. Several very common beetles of the family *Coccinellidæ*, the "lady bugs" are useful destroyers of bark-lice. One of the smallest of this family, *Hyperaspidius coccidivorus*, is found to colonize upon the trunks of orange trees, thickly infested with Chaff Scale, and entirely free them of the pest. The young of a lace-wing fly (*Chrysopa*) feeds upon the bark-lice in all stages, and frequently makes its case of scales torn from the bark, and often still containing living occupants. The orange basket-worm (*Psyche confederata* Gr. & Rob.) has the same habit, and the caterpillars of at least two moths are bark-louse eaters. One of these (an unknown Tineid) inhabits silken galleries, which it covers with half-eaten fragments of scales, and performs such efficient service that every scale in its path is removed from the bark and suspended in the investing web.

The most important external enemies of the Scale insect are certain mites, which are omnipresent upon trees infested with Scale, and which feed upon the eggs and young lice. They breed rapidly and lurk in great numbers under old deserted scales, where their eggs are extremely well protected from the action of insecticides. For this reason, when an effective application has been made by spraying infested trees, the trunks should not be scraped for some time after, but the dead scales should be allowed to remain upon the bark for several weeks, in order that the mites which they harbor may be given time to complete the work of the remedy used. In this they may be confidently relied upon as powerful auxiliaries. When large numbers of the scales have been killed by spraying with oils, &c., the mites are often observed to increase suddenly, as they are much less affected by the application than the Scale insects themselves. It seems probable that they feed upon the dead and dying coccids as well as upon the living, and the loosening of the scales and abundance of food at such times stimulates them to rapid increase. They soon swarm in such numbers as completely to exterminate the remnant of the coccids left alive by the wash.

Of all its enemies, the most efficient destroyers of the Scale insect are its hymenopterous parasites. These are minute four-winged flies, which bore through the scale and deposit within a single egg. The little grub hatching from this egg feeds upon and destroys the occupant of the scale and completes its own transformations in its place. When fully adult the parasite emerges through a round hole eaten in the shell, leaving behind an empty domicile to serve as a shelter for the mites.

The numerous species of these parasites, although not invariably confined in each case to a single species of bark-louse, have distinct methods of attack from which they do not vary. Thus the Long and the Purple Scales are parasitized at about the time of impregnation of the females, or when they are not more than one-half their adult size and the young hymenopteron is developed entirely within the body of the coccid. The skin of the latter hardens when life is extinct and doubly protects the parasite during the latter part of its larval and in its pupa stage. The parasite of the Chaff Scale makes its attack at a later stage, often when the scale is full of eggs and its larva does not enter the body of the coccid, but feeds upon it and the eggs indiscriminately, occasionally devouring the eggs alone and leaving the mother coccid untouched. Its pupa is formed naked within the scale and has only such protection as this affords the coccid and its eggs. In individual numbers these hymenopterous parasites abound to such an extent that rarely less than 25 per cent. and often more than 75 per cent. of the scales are cked by them, and the work of destruction accomplished through ir agency alone equals if it does not excel that of all other enemies bined. Doubtless without their aid the culture of the orange and ted trees would, in Florida at least, become impracticable.

rdinarily the various checks upon their increase are sufficient to pret the spreading of bark-lice to an injurious extent, but at times they rease so rapidly that they entirely outstrip their enemies, and all rts of the plant become thickly coated with scales. The growth of the e is then checked, the infested twigs and branches die, and often e entire upper portion of the tree is lost. The roots and trunk, hower, survive, and the tree endeavors to repair the injury by throwing t shoots from below. When a tree reaches this impoverished condin, matters usually begin to mend. The bark-lice upon the dead or ing branches perish by starvation, the parasites reassert their sway, d slowly the tree regains its health and vigor, but seldom its prisne beauty.

The causes which excite such sudden outbursts of the pest are not learly known, but it may be conjectured that peculiar conditions of the ap are especially favorable to the development of Scale insects, and, erhaps, affect the reproductive function, stimulating the females to reater productiveness. Experiments upon this point have not been onclusive, but observations show that individual females vary considerbly in the number of eggs deposited, and that they attain their maxium size and productiveness when in the full tide of increase upon infested trees. There is a wide-spread and apparently well-founded pinion that vigorous trees are in little danger from attacks, but if from any cause a tree becomes enfeebled, its investment is only a question of time. Many persons refuse to apply insecticides, relying upon their ability to keep their trees vigorous, or to restore them when out of condition by the liberal use of fertilizers. It cannot be denied that this course of treatment is very often successful, but over-stimulation by means of fertilizers is apt to defeat its object, and numerous failures from unknown causes might be recorded.

The utter inadequacy of nearly all the washes hitherto used has led many fruit-growers to despair of obtaining permanent benefit from the application of remedies, and a common practice has been to cut back badly-infested trees, leaving only the main trunks, or in the case of well-grown trees, a portion of the main branches, and to scrub thoroughly every part of these with solutions of soap or lye, using a stiff brush, and as far as possible removing every scale. This, however, involves great care and considerable labor, and the complete extermination of the pest is rarely accomplished in this way. The loss of branches is indeed replaced with extraordinary rapidity, but the Scale insects reappear as if by magic, and in one or two years become as bad as before.

The opinion is often expressed that the tree will "throw off the scales," or that they will "disappear in time at the ends of the branches." The facts upon which this belief is founded are simply that the young lice, when the branches become crowded, wander off and on to new growth; their course is, therefore, naturally upward and outward. When the advancing army reaches the ultimate branches, the insects crowd upon the smaller twigs and leaves, killing them rapidly and involving themselves in the common destruction. The tide of scales is then checked, while the enemies thrive and multiply, feeding upon the dead and starving coccids. There then occurs one of those sudden oscillations of the balance which are familiar enough to entomologists; the unseen enemies increase and the scales visibly diminish. The tree meantime has rest and time to recover its vigor, and the trouble for the time being is over It is, however, a mistake to suppose that all the scales are disposed of or that this is the invariable termination of the pest. There are not unfrequently inundations of the destroyer which involve entire orchards in their resistless course, and remain for years, blasting successive crops of fruit and permanently destroying the symmetry of the trees.

Very young orange trees seldom exhibit these phenomena of the disappearance of scale with little injury to the trees. Their tops being small, and the branches few and short, they are usually entirely overrun in a single season, and, if not attended to, sustain irreparable injury, resulting, in the case of budded trees, in the destruction of the budded portion. For obvious reasons in young groves of budded trees the cutting-back process is not often resorted to, and the only alternative has been to go over the trees with a brush or swab, using cleansing soap or lye solutions, and removing by hand as far as possible all the scales. In this way young trees may be for a time relieved, but while the enemies and parasites are nearly exterminated a sufficient number of scales to restock the plant inevitably escape detection. The bark is at the same time cleared of obstructions to their spread, and the operation has to be repeated at intervals of three or four months. By this laborious and expensive process many groves are brought through the critical period of adolescence and reach the bearing age, but the seeds of mischief remain a constant menace for the future.

In the preceding pages I have endeavored to show, from a brief examination of their history and structure, that Scale insects become less vulnerable as they grow older; that during the earlier portion of their existence, which I have termed the migratory age, they are easily assailable, and although this age is of short duration, and not strictly limited to any season of the year, the months of March, June, and September, which mark the appearance of successive broods, are those in which the application of remedies gives the greatest advantage. Various methods of treatment have been reviewed and their advantages and disadvantages discussed. Finally, the work of enemies and parasites has been indicated sufficiently at least to show their importance and the danger of interfering with their operations by means of half remedies.

REMEDIES—THE ACTION OF INSECTICIDES.

It remains to examine the action of insecticides and to give the results of experiments made during the past season, 1881-'82, under the direction of Professor Riley, the Entomologist of the Department of Agriculture.

From what has been said of the nature and structure of the horny covering that protects the three Diaspinous scales, with which we are chiefly concerned, it will be seen that application of solid substances are not likely to prove practicable, and that for cheap and effective remedies we must look to penetrating liquids. The cost of alcohol renders its extensive use as a solvent impracticable. The volatile oils are as a rule powerful insecticides, but as they reach the insect from beneath by penetrating the bark of the tree, and are all to a greater or less degree injurious to vegetation, their use undiluted can in no case be recommended. Some of the light oils, *e. g.*, naphtha, turpentine, &c., are extremely hazardous remedies, and experiments with them are known to have resulted in the destruction of the orange trees upon which they were applied.

KEROSENE.—The value of this substance as an insecticide is too well known to need further testimony here. Of all the light oils which I have tried, or of which I have any knowledge, it is the least injurious to plants of the Citrus family. Refined kerosene, separated from the deadly naphtha oils, has frequently been used undiluted, without injury.

Crude petroleum is said to destroy the bark, and even the refined oil, if applied in the hot sunshine, completely defoliates the tree. Applied in the shade, at sunset, or in cloudy weather I have never known any serious injury to result from its moderate use. The tree invariably loses the old and devitalized leaves, but young and vigorous growth, especially tender sprouts and budding leaves, are entirely unharmed by it. Nevertheless, so many cases of loss are reported that its use, undiluted, must be considered dangerous. In very fine spray, and with proper precautions, pure kerosene can probably be used with impunity, but all attempts to apply it in small quantities with other liquids, by dashing them together, should be discouraged as dangerous, or at best unsatisfactory, since it is impossible in this way to insure an even distribution of the oil to all parts of the plant.

There is, however, a safe and ready method of diluting kerosene and similar oils, and rendering them miscible with water. This method, as has been indicated by Prof. C. V. Riley (Scientific American of October 16, 1880), is to emulsify the oil with milk.

The want of success which has attended former experiments with emulsions of kerosene and milk (see Department Report, 1880, page 288) is due solely to failure in properly combining the ingredients, and the consequent use of an imperfect or unstable emulsion. The process of forming a perfectly stable emulsion of kerosene and milk is comparable to that of ordinary butter making, and is as follows: The oil and milk in any desired proportions are poured together and very violently dashed or churned for a period of time, varying with the temperature, from fifteen to forty-five minutes. The churning, however, requires to be much more violent than can be effected with an ordinary butter-churn.

The Aquapult force pump, which is also the most effective instrument I have seen for spraying orange trees, may be satisfactorily used for this purpose where moderate quantities only are required. The pump should be inserted in a pail or tub containing the liquids, which are then forced into union by continuous pumping back into the same receptacle through the flexible hose and spray-nozzle. After passing once or twice through this pump the liquids unite and form a creamy emulsion, in which finely divided particles of oil can plainly be detected. This is as far as the process can be carried by stirring or by dashing in an ordinary churn; the product at this point will not bear diluting with water and separates or rises at once to the surface. On continued churning through the pump the liquid finally curdles and suddenly thickens to form a white and glistening butter, perfectly homogeneous in texture, and stable.

The whole amount of both ingredients solidify together, and there is no whey or other residue; if, however, the quantity of the mixture is greater than can be kept in constant agitation, a portion of the oil is apt to separate at the moment of emulsification and will require the addition of a few ounces of milk and further churning for its reduction.

This kerosene butter mixes readily in water, care being taken to thin it first with a small quantity of the liquid. The time required to "bring the butter" varies with the temperature. At 60° F. it is half to three quarters of an hour; at 75°, fifteen minutes, and the process may be still further facilitated by heating the milk up to, but not past, the boiling point. Either fresh or sour milk may be used, and the latter is even preferable.

The presence of kerosene does not prevent or hinder the fermentation of the milk; on standing a day or two the milk curdles, and although there is no separation of the oil the emulsion thickens and hardens and requires to be stirred, but not churned, until it regains its former smoothness.

If sour milk is used no further fermentation takes place, and if not exposed to the air the kerosene butter can be kept unchanged for any length of time. Exposure to the air not only permits the evaporation of the oil but also of the water necessary to hold the oil in emulsion; the kerosene slowly separates as the emulsion dries up and hardens.

Kerosene emulsions may be made of almost any strength; the quantity of milk required to hold the oil does not exceed one-tenth. But emulsions containing over 80 per cent. of the oil have too light a specific gravity and are not readily held in suspension in water. On the other hand, in the process of emulsification, kerosene loses a portion of its value as an insecticide, and emulsions containing less than 30 per cent. of the oil, although they do not at all, or only very slowly, rise to the surface when diluted with considerable quantities of water, are nevertheless too much weakened for effective use against Scale insects.

The killing power of a diluted emulsion depends less upon the amount of emulsion used in the solution than upon the percentage of oil contained in the emulsion. To increase the efficiency of an application we should rather add to the percentage of oil in the emulsion than increase the gross amount of emulsion used in a single application, the amount of the diluent remaining in each case the same. As the result of numerous experiments I would recommend an emulsion consisting of refined kerosene 2 parts; fresh, or preferably sour, cow's milk, 1 part (percentage of oil, 66⅔). Where cow's milk is not easily obtained, as in many parts of this State, it may be replaced by an equivalent of condensed milk (Eagle brand) diluted with water in the proportion 1 to 2. As the cans of condensed milk usually sold in the stores contain exactly 12 fluid ounces (three-quarters pint), the following receipt will be found a convenient one:

Kerosene	1 gallon	= 8 pints	= 64 per cent.
Condensed milk	2 cans	= 1½ "	= 36 per cent.
Water	4 cans	= 3 "	

Mix thoroughly the condensed milk and water before adding the oil; churn with the Aquapult pump until the whole solidifies and forms an ivory-white, glistening butter as thick as ordinary butter at a temperature of 75° F. If the temperature of the air falls below 70°, warm the diluted milk to blood heat before adding the oil.

In applications for Scale insects the kerosene butter should be diluted with water from 12 to 16 times, or 1 pint of butter to 1½ gallons (for Chaff Scale); 1 pint of butter to 2 gallons (for Long Scale). The diluted wash resembles fresh milk, and if allowed to stand, in two or three hours the emulsion rises, as a cream, to the surface. The butter should therefore be diluted only as needed for immediate use, and the mixture should be stirred from time to time.

A wash prepared in accordance with the above directions will kill with certainty all the coccids and their eggs under scales with which it can be brought into direct contact. No preparation known to me will, however, remove the scales themselves from the tree, or in any way reveal to the unassisted eye the condition of the insects within. This can be ascertained only by microscopic examination of detached scales. Time alone, and the condition of the tree itself, will indicate the result of an application. Kerosene, it is true, loosens the scales from the bark, so that for a time they are readily brushed off, but they afterwards become more firmly adherent, and are very gradually removed by the action of the weather.

Upon trees thickly infested a large proportion of the scales are so completely covered up by the overlapping of other scales, or the webbing together of leaves by spiders and other insects, that the wash cannot be brought into direct contact with them, and they are only reached, if at all, by the penetrating action of the oil. This takes place gradually, and the number of bark-lice killed increases for some time after an application, reaching the maximum in the case of kerosene about the fifth day. In Long Scale the oil penetrates the outer end, killing first the eggs at the broad and thin outer end, but its action is gradually exhausted and several pairs of eggs in the middle of the scale are often left alive. It is, therefore, impossible, in a single application, to destroy every scale upon an orange tree. This can, however, be accomplished by making two or three applications at intervals of four or five weeks. The mother insects being nearly or quite all killed by the first treatment, and the surviving eggs having in the interval all hatched, a second application, if thorough, will clear the tree.

The great difficulty experienced in reaching every part of the tree renders it absolutely necessary that any liquid used should be applied in fine spray and with considerable force. An ordinary garden syringe does not acomplish this and can never be used satisfactorily against Scale insects.

The most effective instrument known to me is the Aquapult force pump. This throws a constant stream of moderately fine spray with such force that the fluid is driven into close contact with the bark, and on striking the leaves and branches is dashed into fine mist which envelops the tree and wets every leaf. The tree should always be sprayed from each of four sides, and rather more liquid should be used than seems necessary to drench every portion.

Although I have thought it advisable to recommend several applications, a single very thorough spraying with a good force pump will, in most instances, prove entirely effectual in clearing the tree, since, if only an occasional egg or coccid escapes, the great army of parasites and enemies will be almost sure to complete the work.

As has been already said, diluted kerosene does no injury to young growth or to the bark of the orange trees. It however causes the older leaves to drop, and where the tree is badly infested with scale or otherwise out of condition the defoliation is sometimes complete, especially if the wash is applied in the sun. The death of moribund branches and twigs is also hastened. Beyond this the injury, if such it be considered, is imperceptible, and dormant trees are invariably stimulated to push out new growth in two or three weeks after treatment.

Even in midwinter, if the weather is mild, sprouts will show themselves, and this is perhaps the only objection to its use at this season, for it is clearly not desirable to start the buds at a time when there is danger of frost. During the past winter (1881–'82) I have experimented with many young trees, using emulsions containing from 40 to 80 per cent. of kerosene, and in no case has any real injury resulted, although some trees in very bad condition have lost a portion of their twigs and smaller branches that had been long infested with scale and were in a dying condition. In the spring, when the trees are in full growth and covered with tender sprouts, they may be sprayed with the diluted emulsion recommended above, without danger of checking their growth.

In Table 1 are given the results of seventeen experiments with kerosene in milk emulsions of varying strength. When the percentage of coccids killed is given this was obtained by cutting twigs, leaves, and portions of infested bark from all parts of the tree, and examining microscopically in the laboratory large numbers of the scales upon them. Under the head of young coccids are included all those which have well-formed scales but have not begun to lay eggs. The youngest bark-lice, or those which have not yet molted, were almost invariably killed and are not included in the enumeration.

The percentage of young coccids killed is given separately, including under this head all ages between the formation of the permanent scale and the appearance of eggs, but no larvæ before the first molt; the latter were in nearly every case all killed. Of scales which contained eggs three classes were examined, and the percentage of each obtained: (1) Scales in which a portion only of the eggs were destroyed; (2) Scales in which all the eggs were killed; (3) Scales in which no eggs were killed.

Purple Scales (*Mytilaspis citricola*) were not abundant but appear to be somewhat less readily destroyed than Long Scale. All the experiments were made upon young orange trees from three to six years old. An Aquapult pump of medium size was used, and in each case the trees were sprayed from the ground and on four sides. Where the trees were more than eight or ten feet in height, the upper branches did not receive the spray with sufficient force and show in some cases a smaller percentage of bark-lice destroyed than the lower portions of the same tree. For full-grown trees a larger pump is needed and the apparatus should be placed in a cart or otherwise raised above the ground when used.

The emulsions used were made as follows:

No. 2. Kerosene, 1 pint; sour cow's milk, 2 fluid ounces, dashed with a ladle; 2 drachms of powdered chalk was first added to the milk, and 2 ounces water during the stirring.

An imperfect emulsion not readily suspended in water.

No. 3. Kerosene, 1 quart; solution of condensed milk, 3 parts; water, 5 parts, 12 fluid ounces.

Emulsion made by spraying through the Aquapult pump and back into the pail. Stable, and readily suspended in water.

No. 9. Kerosene, 1 quart; condensed milk, 12 fluid ounces, diluted with water, 36 ounces; emulsified with the Aquapult.

No. 10. Kerosene, 25.6 fluid ounces; condensed milk, 4.8 fluid ounces; water, 14.4 ounces; emulsified with pump.

No. 11. Kerosene, 2 quarts; condensed milk, 12 fluid ounces (1 can); water, 20 ounces; with pump.

No. 13. Kerosene, 2 quarts, 4 fluid ounces; condensed milk, 12 fluid ounces; water, 24 ounces; with pump.

WHALE-OIL SOAP.—This has long been considered one of the best insecticides known, and is extensively used as a remedy for bark-lice. Experiments show that very strong solutions kill the coccids but have little or no effect upon their eggs. Solutions of one pound of the soap to three gallons of water failed to kill the adult bark-lice or their eggs, and did not destroy all the young. The strongest solution used, one pound of the soap to one gallon of water, killed all the coccids and few or none of the eggs.

This solution solidifies on cooling, and must, therefore, be applied hot. The effect upon the trees is about equal to that of effective kerosene emulsions; badly infested trees are somewhat defoliated, but new growth and vigorous trees are not appreciably affected. As the eggs are not killed, several applications at intervals of four to six weeks will be required to clear a tree of scale.

Whale-oil soap is sold in Eastern Florida at 10 to 12 cents per pound. The cost of an effective wash is therefore much greater than emulsions of kerosene. For scrubbing and cleansing the trunks of orange trees this soap may be recommended. A solution of 1 pound to 4 gallons will probably be sufficiently strong for this purpose.

In Table 2 are given the results of experiments with solutions of whale-oil soap applied in fine spray to all parts of the trees by means of the Aquapult pump. The solutions were all applied hot, being either solid when cool or too thick for spraying through the pump.

OIL OF CREOSOTE.—The crude oil, dissolved in strong alkalies or solutions of soap, forms a very effective remedy for Scale insect. It may also be emulsified with milk in the same manner as kerosene. The undiluted oil is, however, exceedingly injurious to vegetation, and destroys the bark of orange and other trees. It is, in fact, a more dangerous substance than kerosene, and requires to be used with great caution. Solutions, emulsions, and soaps containing it should be very carefully mixed, in order that no globules of free oil may be allowed to come in contact with the bark of the tree.

Its action upon the Scale insect is even more powerful than kerosene, but it does not destroy as large a percentage of the eggs. The effect upon the coccids is not immediate, as in the case of other insecticides, and for three or four days after an application very few of the insects die. At the end of a week, however, the bark-lice are found to be affected and continue to perish in increasing numbers for a week longer. Even after the lapse of three weeks the destructive action of the oil is still appreciable. These facts lead me to suspect that the insects are killed, in part at least, by the poisoning of the sap upon which they feed.

The visible effect upon the plant appears to confirm this view. Leaves upon infested trees begin to drop after four or five days, and the defoliation reaches a maximum during the second week. As is the case with kerosene, the effect upon the tree depends upon its condition at the time of application; but creosote is more severe in its action, and there is greater loss of leaves and infested branches. With care, however, an application of creosote may be made sufficiently strong to exterminate the scale without serious injury to the plant, and, as new or vigorous growth is very slightly affected, recovery is rapid.

The following solution of crude oil of creosote will be found nearly if not quite as effective as a 64 per cent. kerosine emulsion, and may be applied without danger to orange trees. Dilute the creosote with twice its volume of soap solution (2 ounces common soap to 1 pint hot water). Mix thoroughly until all the oil is dissolved. Add, before using, to one part of the above solution nine parts water, and apply in as fine spray as possible.

The most effective method of using creosote is to saponify it with heavy oils and potash. In this way I have succeeded in obtaining a solid soap containing about 12 per cent., by volume, of the oil. The process of making the soap is, however, exceedingly tedious and difficult, and unless proper appliances be used the resulting product is imperfect and even dangerous to use, as it contains a large amount of free creosote. Manufacturers of carbolic soap could undoubtedly supply a better article and at a less cost than the consumer could make for himself.

In Table 3 are given results of experiments with oil of creosote in solution and combined with other substances.

In experiment No. 27, 9 fluid ounces of creosote was applied t
single tree about five years old. The tree, which was badly infes
with Long Scale, and had many branches dead or dying, was sever
defoliated, and lost some moribund branches, but recovered in six we
and pushed out new growth in midwinter.

In experiment No. 30 a pint measure of crumbled creosote soap
applied. The actual amount of creosote contained in this soap did
exceed 2 fluid ounces. The extermination of Long Scale was comple
The tree, which was very badly infested and in poor condition,
almost completely defoliated and lost half its branches, but recove
very rapidly and pushed out new leaves within thirty days. (Janu
25.)

In experiment No. 21 the other substances added to the creosote
lution increased the injury to the foliage of the tree and it was ve
severely checked, but entirely recovered and was stimulated to vig
ous growth at a time when all surrounding trees were dormant.

In the remaining experiments, 13, 14, 15, and 12, the quantity of cr
sote used was not sufficient to kill the Scale insects. The effect up
the trees was also very slight.

Although from the greater danger which attends its use and its le
effective action upon the eggs, creosote cannot be preferred to kerose
as a remedy for scale, orange growers will be glad to find in it a speci
against certain destructive bark fungi which are often mistaken
scale and are very frequently associated with it. One of these fun
is very widely distributed in Eastern Florida, and in some groves affec
the health and endangers the life of every tree. It appears upon t
trunk and branches as little, hard excrescences, of gray color, som
times bursting at the end and disclosing a white, cottony interior, fro
which they are often confounded with a coccid, and are called t
"mealy bug." A single application of cresote solution will usually e
tirely destroy the mycelium of this fungus within the bark and cau
its disappearance from the tree.

BISULPHIDE OF CARBON.—In Table 4 are given the results of sever
experiments with this insecticide. The emulsion, of which the ingredien
are given in the table, was formed by beating together with a spatu
the carbon and lard oil and then adding the milk and water, and em
sifying in the same manner.

The trees in experiments 40 and 41 were very severely checked,
though not seriously injured, and all subsequently recovered. In expe
ment 39 the mixture was applied during a rain, and was entirely witho
effect upon the tree or scale.

Further experiment is needed to determine whether this substan
can be safely and economically used as a remedy for scale. Althou
a powerful insecticide, the danger to the trees and the cost of the
terials detract greatly from its value. It is also exceedingly volat
and explosive, and is to some extent poisonous to man.

NEAL'S EXTERMINATOR.—This preparation has been used to a limit
extent in Putnam County, Florida, and is superior to most of the p
prietary washes in the market. It is a liquid, soluble in water, and
applied with a brush or in spray. It soon dries when exposed to t
air, and forms a gum, which coats the tree and in part peels off, carryi
with it many of the old dead scales and some living ones. When appli
in sufficient strength it kills most of the coccids but does not destroy t
eggs. It checks the tree rather more than kerosene, with which it ca
not be compared in efficiency or cheapness. The preparation is in

and harmless to man and acts mechanically by covering and stifling the bark-lice or by removing them bodily from the tree.

Table 5 gives the result of a single experiment in which the "exterminator" was diluted in the proportions recommended by the proprietor. In other trials, with stronger solutions, the best result obtained was 80 per cent. of the young coccids killed, and trees were cleared of scale by repeated applications at intervals of several weeks; but in these cases the bark was hardened and the growth of the trees somewhat checked.

Lye.—Four experiments with concentrated potash lye, given in Table 6, sufficiently illustrate the worthlessness of this substance as a remedy. In the strongest solution one pound of solid lye to a gallon and a half of water, all applied upon a single, very small tree, only a small percentage of young Long Scales were killed; Chaff Scales did not appear to be affected, and eggs or adult coccids entirely escaped. The tree was, however, seriously injured, and lost nearly all its leaves, with many of the smaller branches.

Solutions of one pound to two, two and a half, and three gallons had no appreciable effect upon the insects, but all seriously affected the foliage and even the bark of the trees.

Sulphuric acid.—A single experiment with sulphuric acid, 4 fluid ounces in 6 quarts of water, applied with a brush as far as possible to all parts of a young tree, killed nearly all the Scale insects, and very nearly killed the tree. The bark was blackened but not destroyed, and nearly all the leaves dropped. The tree, however, slowly recovered.

Sulphate of iron.—This substance is exceedingly injurious to vegetation, but is, nevertheless, a very common ingredient of patent and proprietary remedies. Its presence can be detected by the inky-black or brown stains which it forms in the substance of the leaves and the rind of the fruit.

It does not affect the Scale insect except by destroying the vegetable tissues from which it gets its subsistence.

Ammonia.—With this in a pure state no experiments have been made, but to its presence in fermenting urine is probably due the insecticide properties of the latter. Applications of urine have often been recommended as a remedy for scale, and are certainly not without value, but if allowed to stand and ferment, and especially if soot or other absorbents of the ammonia are mixed with it, it becomes highly injurious to vegetation, and if applied at all should be greatly diluted. A mixture of soot and fermented urine applied undiluted to a small orange tree effectually cleared it of scales but very nearly killed the tree.

Very many substances used separately, or in various combinations, are recommended as remedies for Scale insect. Among the number I have examined with more or less care the following, and find them to be of doubtful or of no value: sal-soda, muriate of potash, salt, lime, sulphur, soot, and ashes.

Many otherwise valueless washes and applications have been rendered partially effective by the addition of a small quantity of free kerosene. The result in all such cases has been a very unequal distribution of the oil, some portions of the tree receiving a dangerous dose and other portions none at all. It seems hardly necessary to point out the uselessness of such half-way measures in combatting a pest which the most perfect remedy is powerless to eradicate unless applied with thoroughness and care.

TABLE 1.—KEROSENE EMULSIONS.

No. of experiment.	No. of emulsion.	Kerosene in the emulsion.	Emulsion diluted with water.	Amount of diluted wash applied.	Date of application.	Date of examination	Long Scale (*M. Gloverii*).				Chaff Scale (*P. Pergandii*).				Remarks.
								Scales containing eggs.				Scales containing eggs.			
							Young coccids killed.	Eggs, in part killed.	Eggs, all killed.	Eggs, none killed.	Young coccids killed.	Eggs, in part killed.	Eggs, all killed.	Eggs, none killed.	
		pr. ct.	*Parts.*	*Qts.*			*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	
10	2	80	1 to 16	10	Oct.	Oct. 22	99	39	61	0	.....	.....	.....	.....	Bark, leaves and twigs of lower branches.
						Oct. 25	93	58	29	13	.....	.....	.....	.....	Thorns from upper branches. November 10, a few gravid females still living, also a few young scales forming from eggs recently hatched.
10	11	67	1 to 16	6	Nov. 14	Nov. 17	....	.....	.....	.....	.....	.....	.....	.....	Second application effectively cleared the tree of scales; only an occasional gravid scale found alive on upper branches.
11	3	73	1 to 64	6	Oct. 22	Oct. 25	25-30	.....	0	99+	.....	.....	.....	.....	No appreciable effect upon eggs or mature coccids.
29	11	67	1 to 9½	6	Nov. 14	Nov. 19	71	43	18	39	.....	.....	.....	.....	Thickly infested bark of lower limbs. Upper branches give variable results.
						Dec. 26	100	.....	100	.....	.....	.....	.....	.....	Bark, twigs, and leaves from all parts. Prolonged examination: not a living coccid or egg can be found. Mites swarm under the dead scales and have probably completed the work of the wash.
24	11	67	1 to 16	6	Nov. 11	Nov. 18	91	37	19	44	63	65	0	35	
28	11	67	1 to 16	6	Nov. 14	Nov. 19	....	.....	.....	.....	.....	.....	.....	.....	Result about the same as in No. 24, or slightly less effective and variable.
25	11	67	1 to 16	4	Nov. 11	Nov. 19	78	29	8	63	.....	.....	.....	.....	Variable; some branches give poor results. Evidently not enough liquid used for thorough application.
31	11	67	1 to 16	3	Nov. 14	Nov. 18	....	.....	.....	.....	22	.....	5	95	Small tree, but not sufficient wash used. Effect on Long Scale about equal to No. 25. Lecanium Scales killed only where the spray struck with force.
26	11	67	1 to 16	2	Nov. 11	Nov. 19	....	.....	.....	.....	.....	.....	.....	.....	Small tree, but amount of wash applied entirely insufficient. Many branches show no effect. Very few Long Scale killed.
38	13	65	1 to 16	6	Dec. 8	Dec. 12	....	.....	.....	.....	.....	.....	.....	.....	Result about the same as in No. 24. Second application four days later.
38	13	65	1 to 16	9	Dec. 12	Feb. 4	....	.....	.....	.....	.....	.....	.....	.....	Almost complete extermination of Long Scale. A few living coccids found upon a twig from upper branches. On the same twig a few living Chaff Scale were also found.

17	10	57	1 to 16	6	Nov. 4	Nov. 9	25 to 50	......	......	......	......	......	......	......	Action very unequal upon different parts of the tree. Examination made too soon after application to show full effect of the wash.
18	10	57	1 to 16	6	Nov. 4	Nov. 10	......	......	......	......	Few	......	......	......	Effect upon Chaff Scale very slight. On some leaves nearly all killed.
						Jan. 30	......	......	......	......	......	......	......	......	Tree less infested than formerly and condition much improved, but not cleared of scales. Chaff Scale beginning to increase again. Some Long Scale still living.
20	9	40	1 to 8	6	Nov. 4	Nov. 10	......	......	......	......	......	......	......	......	Chaff Scale not appreciably affected. Long Scale killed to some extent. *Lecanium hesperidum* not killed.
						Jan. 30	......	......	......	......	......	......	......	......	Application not effective in clearing the tree. Chaff Scale will soon begin to increase.
16	9	40	1 to 11	6	Nov. 3	Nov. 9	45	37	14	49	......	......	......	......	Leaves and twigs .... Chaff Scale much less affected.
						Nov. 9	36	......	......	......	......	......	......	......	Exposed bark of upper branches.
						Nov. 10	72	20	19	61	......	......	......	......	Leaves, twigs, and bark of main branches. Chaff Scale less affected; not counted.
						Nov. 11	100	40	0	60	......	......	......	......	A single large leaf.
						Jan. 25	......	......	......	......	......	......	......	......	Long Scale and Chaff Scale beginning to increase and entering upon a new brood.
19	9	40	1 to 24	6	Nov. 4	Nov. 10	......	......	......	......	......	......	......	......	Tree infested with Chaff Scale only. Effect on scales scarcely appreciable.
						Jan. 30	......	......	......	......	......	......	......	......	Application has had little or no effect. Number of living scales has neither increased nor diminished. New brood beginning to hatch.
23	......	......	......	6	Nov. 4	Nov. 11	......	......	......	......	......	......	......	......	Imperfect emulsion made by churning together one-half pint of kerosene, 12 fluid oz. (?) condensed milk, and 6 quarts water. Application very unequal owing to imperfect mingling of the oil and water. Young of Long Scale killed on some branches and not killed on others. Eggs for the most part uninjured. Some infested leaves show all coccids killed on one side; all living on the other side.

TABLE 2—WHALE-OIL SOAP.

No. of experiment.	Whale-oil soap solutions.					Long Scale (*M. Gloverii*).				Chaff Scale (*P. Pergandii*).				Remarks.
							Scales containing eggs.				Scales containing eggs.			
	Soap.	Water.		Date of application.	Date of observation.	Young coccids killed.	Eggs, in part killed.	Eggs, all killed.	Eggs, none killed.	Young coccids killed.	Eggs, in part killed.	Eggs, all killed.	Eggs, none killed.	
	Lbs.	*Qts.*				*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	
34	1	4	4½ quarts applied hot.	Dec. 6	Dec. 17	100	0	0	100	95 (!)	0	0	100	Tree infested with Long Scale, and a few scattered Chaff Scale; nearly every coccid, old and young, killed; a very few Chaff Scale still alive; eggs of both scales absolutely uninjured; tree rather large; not enough liquid used.
					Jan. 28	......	......	......	......	......	......	......	......	Long Scale completely exterminated; eggs and young probably destroyed by mites; living Chaff Scale, nearly all young or nearly adult, numerous on some parts.
33	1	6	6 quarts applied hot.	Dec. 6	Dec. 16	100	24	15	61	......	......	......	......	Small tree; very thorough application; at noon in the sun.
					Jan. 28	......	......	......	......	......	......	......	......	Both Long and Chaff Scale completely exterminated upon nearly all parts of the tree; several twigs, however, have escaped thorough wetting, and are still moderately infested with one or both kinds of scale.
35	1	8	8 quarts applied hot.	Dec. 8	Dec. 17	95	0	0	100	......	......	......	......	Tall tree; difficult to cover with liquid; adult female coccids not all killed.
					Jan. 28	......	......	......	......	......	......	......	......	A few individual Long Scale found alive on some branches; 1 or 2 per cent. living.
36	1	10	5 quarts applied hot.	Dec. 8	Dec. 26	90	0	0	100	......	......	......	......	Small tree; Long Scale which have not completed the first molt are all killed; the proportions given include coccids from passed first molt to adult; a few Chaff Scale seen, all living; no gravid ♀ coccids killed.
37	1	12	6 quarts applied hot.	Dec. 8	Dec. 26	70	0	0	100	0 (?)	0	0	100	Small tree; thorough application; a few Chaff Scale intermingled seem not to have been affected.

TABLE 3—CREOSOTE.

Number.	Oil of Creosote; amount used in single application.		Diluted with water.	Amount of diluted wash applied.	Date of application.	Date of examination.	Long Scale (*M. Gloverii*).				Chaff Scale (*P. Pergandii.*)				Remarks.
								Scales containing eggs.				Scales containing eggs.			
							Young coccids killed.	Eggs, in part killed.	Eggs, all killed.	Eggs, none killed.	Young coccids killed.	Eggs, in part killed.	Eggs, all killed.	Eggs, none killed.	
			Qts.	*Qts.*			*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	
27	9 fluid oz..	Dissolved in soap, 2 ounces; hot water, 1 pint.	4½	6	Nov. 12	Nov. 14	......	......	......	......	......	......	......	......	Long Scale only. Very few young and no eggs killed.
						Nov. 21	94	41	17	42	......	......	......	.....	Bark of vigorous shoot infested with scales of last brood, and nearly all young. All scales before first moult are killed and not enumerated. Older scales still dying.
						Nov. 21	77	21	12	67	......	......	......	......	Leaves from less infested portions of the tree.
						Jan. 25	......	......	......	......	......	......	......	......	Scales completely exterminated upon most parts. In a few places young are forming. On exposed branches very few or no scales alive. Other portions give 3 per cent. living.
30	2 fluid oz...	Creosote soap*—16.8 fluid oz.	6	6	Dec. 5	Dec. 16	100	26	29	45	......	......	......	......	Gravid females all killed. Long Scale only.
						Jan. 25	......	......	......	......	......	......	......	......	On minute and careful examination, not a single living coccid or egg can be found.
47	$1\frac{1}{10}$ fluid oz.	*Id*................9 fluid oz.	6	6	Jan. 10	Jan. 21	100	43	48	9	60	11	4	85	Chaff scales on outside have been killed; scales protected by others overlapping them are alive. Eggs but little affected.
						Feb. 2	......	......	......	......	......	......	......	......	Long Scale nearly exterminated. Chaff Scale but slightly checked, and now increasing.
32	1 fluid oz..	*Id*..............8.4 fluid oz.	6	6	Dec. 5	Dec. 16	99+	20	0	80	......	......	......	......	A single living coccid seen. Eggs slightly affected.
46	½+ fluid oz.	*Id*.............. 4.5 fluid oz.	6	6	Jan. 10	Jan. 21	96	13	2	85	42	0	0	100	Two small trees washed; (1) infested with Long Scale; (2) infested with Chaff Scale. On some twigs of the latter, only ♂ pupæ appear to be killed. Lecanium Scales nearly all killed.

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*Creosote, 12 % by volume; lard oil, 60 % by volume; concentrated lye, 20 % by volume; water, 8 % by volume. (Solidified by long continued boiling. Loss by evaporation estimated, and above proportions given as approximate only.)

TABLE 3—CREOSOTE—*Continued.*

Number.	Oil of Creosote; amount used in single application.		Diluted with water.	Amount of diluted wash applied.	Date of application.	Date of examination.	Long Scale (*M. Gloverii*).				Chaff Scale (*P. Pergandii*).				Remarks.
								Scales containing eggs.				Scales containing eggs.			
							Young coccids killed.	Eggs, in part killed.	Eggs, all killed.	Eggs, none killed.	Young coccids killed.	Eggs, in part killed.	Eggs, all killed.	Eggs, none killed.	
			Qts.	*Qts.*			*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	
46	....	[Continued]	......	......	......	Feb. 2	......	......	......	......	......	......	......	......	Living eggs and young scales found on both trees. Long Scale slightly checked; Chaff Scale not at all.
21	4⅓ fl. oz..	Dissolved in soap, 2 ounces; hot water, 12 ounces; together with silicate of soda, 13 fl. ounces; water, 12 ounces; urine, 7 fl. oz.	4	5+	Nov. 7	Nov. 10 Nov. 19	91 99	56	0	44	......	......	......	......	Many scales full of dead larvæ which have hatched since application, but unable to issue. In many scales the eggs are partly or all killed; mother coccids in many cases still alive. Scales severely checked; no new scales forming.
13	2 fluid oz..	Emulsified with condensed milk, 4 fl. oz.; water, 1 oz.	5	5+	Oct. 26	Oct. 31	......	......	......	......	......	......	......	......	Tree infested with Long Scale. No appreciable effect upon the scales.
14	1.13 fl. oz..	Emulsified with sour condensed milk, 78 pr. ct.; to creosote, 22 pr. ct.	6	6	Oct. 31	Nov. 5	......	......	......	......	......	......	......	......	Long Scale. No appreciable effect.
15	$\frac{8}{10}$ fl. oz..	Emulsified together with 2.7 fluid oz. of kerosene and 2.64 fluid oz. of sour milk curds. Oil creosote ....14 pr. ct. Oil kerosene.......42 pr. ct. Curds of milk .....44 pr. ct.	6	6	Oct. 31	Nov. 5	......	......	......	......	......	......	......	......	Long Scale very slightly affected. Not over 20 per cent. of the young scales killed. No mature females and no eggs killed.
12	⅓ fluid oz.	Solution in water, made by triturating 1 fl. oz. creosote with 2 oz. carb. magnesia and filtering in 1 quart water.	2	2	Oct. 25	Nov. 2	......	......	......	......	......	......	......	......	Long and Chaff Scale. No effect whatever.

TABLE 4.—BISULPHIDE OF CARBON EMULSION.

[Bisulph. carb., 56 per cent.; lard oil, 19 per cent.; condensed milk, 6 per cent.; water, 19 per cent.]

Number of experiment.	Amount of bisulphide used in single application.		Diluted with water.	Amount of diluted wash applied.	Date of application.	Date of examination.	Long Scale (*M. Gloverii*).				Chaff Scale (*P. Pergandii*).				Remarks.
								Scales containing eggs.				Scales containing eggs.			
							Young coccids killed.	Eggs, in part killed.	Eggs, all killed.	Eggs, none killed.	Young coccids killed.	Eggs, in part killed.	Eggs, all killed.	Eggs, none killed.	
			Qts.	*Qts.*			*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	
41	9 fluid oz..	In emulsion, 16 fluid oz	5¼	6	Dec. 31	Jan. 20	52	0	0	100	......	......	......	......	Very tall tree. Application made on a windy day and upper branches not thoroughly sprayed; gives varying results, some young and nearly all eggs alive. Other parts of tree have been entirely cleared of living young, but a large proportion of eggs escape.
							100	35	43	22	......	......	......	......	(*a*) Thorn from upper branches. Long Scale. Leaves, thorns, and twigs from lower branches. Gravid females of Long Scale all killed. A few Chaff Scale examined; coccids killed but eggs alive.
40	5.6 fluid oz..	In emulsion, 10 fluid oz.....	6	4 2	Dec. 31 Dec. 31	Jan. 21 Jan. 21	100	3	96	1	97	0	98	2	Two trees sprayed, one very small; both infested with Long Scale and Chaff Scale together. Trees nearly cleared of scale, in part by the aid of parasites. Application more thorough than No. 41.
39	3 + fluid oz..	In emulsion, 6 fluid oz	6	6	Dec. 15	Dec. 26	......	......	......	......	......	......	......	......	Applied in rain on windy day; not a satisfactory application. No eggs, and apparently no young coccids killed. Examination January 25 gave same result; scales increasing.

TABLE 5.—NEAL'S EXTERMINATOR.

							Long Scale (*M. Gloverii*).				Chaff Scale (*P. Pergandii*).				
								Scales containing eggs.				Scales containing eggs.			
Number of experiment.	Amount of exterminator or potash used in single application.		Diluted with water.	Amount of diluted wash applied.	Date of application.	Date of examination.	Young coccids killed.	Eggs, in part killed.	Eggs, all killed.	Eggs, none killed.	Young coccids killed.	Eggs, in part killed.	Eggs, all killed.	Eggs, none killed.	Remarks.
			Qts.	*Qts.*			*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	*pr. ct.*	
22	16 fluid oz.	Neal's exterminator, diluted 1 to 9.	4½	5	Nov. 7	Nov. 10	43	0	0	100	......	......	......	......	Gravid females and eggs not injured. Chaff Scale; young slightly affected, eggs not at all.

TABLE 6.—POTASH SOLUTIONS.

42	1 pound...	Concentrated potash lye, 1 lb.	6	6	Dec. 31	Jan. 20	37	0	0	100	......	......	......	......	Only a few Chaff Scales examined; all of them alive.
43	1 pound...	......do ....1 lb.	8	8	Jan. 2	Jan. 9	......	......	......	......	......	......	......	......	Long Scale only. No appreciable result.
44	½ pound...	......do ....1 lb.	10	5	Jan. 2	Jan. 9	0	0	0	100	0	0	0	100	Long and Chaff Scale together. No result whatever.
45	½ pound...	......do ....1 lb.	12	6	Jan. 2	Jan. 9	0	0	0	100	0	0	0	100	Do.

NOTE.—The above report by Mr. Hubbard is a summary of practical work done in the orange insect investigation at Crescent City, Florida, and is prepared at our request in advance of the special report on the subject. It is especially valuable because of the thorough experiments with kerosene which it embodies. Not that they are final, for other satisfactory methods of emulsifying petroleum have been obtained by other experimenters and give promise of usefulness. We have for years been endeavoring to solve the question of the safe and effective use of petroleumon plants because of its well-known value and wide application as an insecticide. Emulsions with soapsuds and lye had been worked at some years ago by Professor Taylor, the microscopist of the Department, and more recently they have been made by several independent experimenters in Florida, but particularly by Mr. Joseph Voyle, an intelligent correspondent at Gainesville, who uses kerosene, soap, and fir-balsam combined at a high temperature, and produces a permanent paste which he calls "murvite," readily soluble in water. Recent experiments made at our request by Mr. Clifford Richardson, assistant chemist of the Department, with ordinary soap, whale-oil soap, and both light and heavy oils, also show that 20 parts hard soap, 10 parts water, 40 parts kerosene and one part balsam, produce the most satisfactory results. The substances may be readily mixed into a permanent paste which dilutes *ad libitum* with water, forming a milk-like fluid upon which a slight cream in time rises, but which is always easily rendered homogeneous upon slight shaking. Mr. Hubbard's experiments would indicate, however, that for insecticide purposes, nothing equals the milk emulsions which were first suggested by Professor Barnard, during our work on the Cotton Worm at Selma, Ala., in 1880, and though the use of ordinary emulsifying agents, as various mucilaginous substances and the phosphates, lactophosphates and hypophosphites of lime may facilitate the making of kerosene emulsions, we have not yet had them sufficiently tested as insecticides, and for the present can recommend nothing more simple and at the same time more available to the average farmer than the permanent milk emulsion as produced by Mr. Hubbard.—C. V. R.